THE QUANTITATIVE UTILIZATION OF UREA NITROGEN BY MATURE AND GROWING SHEEP

BY

LORIN E. HARRIS

B. S., Utah State Agricultural College, 1937
M. S., University of Illinois, 1938

AN ABSTRACT OF A THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN ANIMAL HUSBANDRY IN THE GRADUATE SCHOOL OF THE UNIVERSITY OF ILLINOIS

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I. INTRODUCTION

Since the middle of the last century, considerable information has been gathered concerning the feeding of non-protein forms of nitrogen to animals. Particularly in Germany, the investigations have been devised to find a cheap source of nitrogen for animals. The results show that ruminants, at least, can utilize non-protein nitrogen such as that furnished by urea. The generally accepted theory is that ruminants, with their large rumen, containing various bacteria, protozoa, and other forms of microscopic life, utilize non-protein nitrogen through the symbiotic action of these mono-cellular organisms. These organisms in turn are digested and utilized by the ruminant in the abomasum and intestine. Thus the rumen is looked upon as a "protein factory".

None of the experiments on urea feeding, with one exception, has been planned to show how much of the nitrogen of urea is utilized and with what efficiency. The one exception, reported by Miller and Morrison ('38), indicated a surprisingly low utilization of urea nitrogen. It was thought that, from a scientific as well as from a practical standpoint, the quantitative utilization of urea nitrogen should be investigated further.

II. EXPERIMENTAL METHODS

All of the experiments in this investigation were carried out on sheep. Two methods of study were employed. The first was the study of the utilization of urea nitrogen for maintenance by the nitrogen balance method, in which the biological value was determined by the procedure employed by Mitchell ('24). Ten sheep were used in this study.

The second was the study of the utilization of urea nitro-

gen for growth. A long continued feeding test was conducted in which growth and balance data, supplemented by slaughter data of check lambs at the beginning and of the test lambs at the end of the feeding period, were obtained. By using the information on the losses of endogenous nitrogen in the urine, and of metabolic nitrogen in the feces on the maintenance sheep, the biological value of urea nitrogen was calculated for growth. Twenty-three lambs were used in this phase of the investigation.

The results secured seem to justify the following conclusions.

III. CONCLUSIONS

1. The addition of urea or casein to a low-nitrogen ration improves food consumption, and, consequently, gains in body weight.

2. It requires 201 mgms. of urea nitrogen and 160 mgms. of casein nitrogen per kilogram of body weight or 7865 mgms. urea nitrogen and 6261 mgms. of casein nitrogen per square meter of body surface for the maintenance of nitrogen equilibrium of sheep weighing about 36 kgms. This is equal, respectively, to 9.06 and 7.25 percent protein equivalent in the ration on a dry matter basis. Thus, urea nitrogen is only 79.5 percent as valuable in maintenance nutrition as casein nitrogen.

3. The excretion of nitrogen through the skin is independent of the amount or kind of nitrogen compounds fed in the ration.

4. The endogenous nitrogen in the sheep averages 30.4 mgms. per kilogram of body weight, or 1190 mgms. of nitrogen per square meter of body surface.

5. The metabolic nitrogen varies with the dry matter consumed. In the sheep it is equal to 0.562 gms. nitrogen per 100 gms. of dry matter consumed.

6. The creatinine excretion in the sheep is constant from day to day and is equal to 23 mgms. per kilogram of body weight of sheep weighing 27 to 42 kgms.

7. The creatine excretion is very variable in the sheep and seems to depend upon the type of ration fed, though other factors may also operate.

8. The digestibility of dry matter and cellulose in a low-nitrogen ration is stimulated by the addition of urea, but the digestibility of lignin is apparently not affected.

9. Growing lambs require between 11 and 15 percent protein equivalent in a ration for maximum gains in body weight when urea provides 50 to 62 per cent of the nitrogen fed.

10. Between the limits of 8 and 15 percent protein equivalent the chemical composition of the tissues formed during the growth of lambs may not be affected by the adequacy or inadequacy of the ration with respect to nitrogen.

11. The biological value of urea nitrogen at the level which just supports nitrogen equilibrium is 59 and that of casein nitrogen is 68.

12. At a level of 15 percent protein equivalent, the biological value of urea (plus the nitrogen in the basal ration, ranging from 38 to 66 percent) is 41; at 11 percent, it is 58; and at 8 percent, it is 74.

13. Urea possesses toxic effects if fed at high levels, but, at the levels studied in this investigation, it produced no obvious deleterious effects. It may produce renal hypertrophy when fed at a level of 3.15 percent of the dry matter.

REFERENCES

Mitchell, H. H., 1924. A Method of Determining the Biological Value of Protein. J. Biol. Chem. 58:873-903.

Miller, J. I., and Morrison, F. B., 1938. The Nutritive Value for Farm Animals of the Proteins Furnished by Common Protein-rich Supplements and by Typical Legume and Non-legume Rations. New York (Cornell) Exp. Sta., Fifty-first Annual Rept., p. 91.

VITA

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